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(54) Document image assessment system and method

(57) A system and method in accordance with the present invention includes a scanning assembly and a storage device coupled to a programmed computer with a set of instructions for carrying out an assessment of a document image. The system and method operate by: processing the document image to obtain one or more attributes related to the geometrical integrity of the document image; selecting a threshold value from a database for each of the obtained attributes; and then comparing each of the obtained attributes against the threshold value selected for the obtained attribute to determine a difference for each and then evaluating one or more of the differences using predetermined criteria to provide evaluation results of the geometrical integrity of the document image. The system and method may also operate to: process the document image to obtain attributes related to line skew, average character confidence, expected contrast, and sharpness in the document image; select a threshold value from a database for each of the obtained attributes; and compare each of the obtained attributes against the threshold value selected for the obtained attribute to determine the difference for each and then evaluate one or more of the differences using predetermined criteria to provide evaluation results of the condition of the text of the document image and of the condition of the image with respect to a fixed reference.

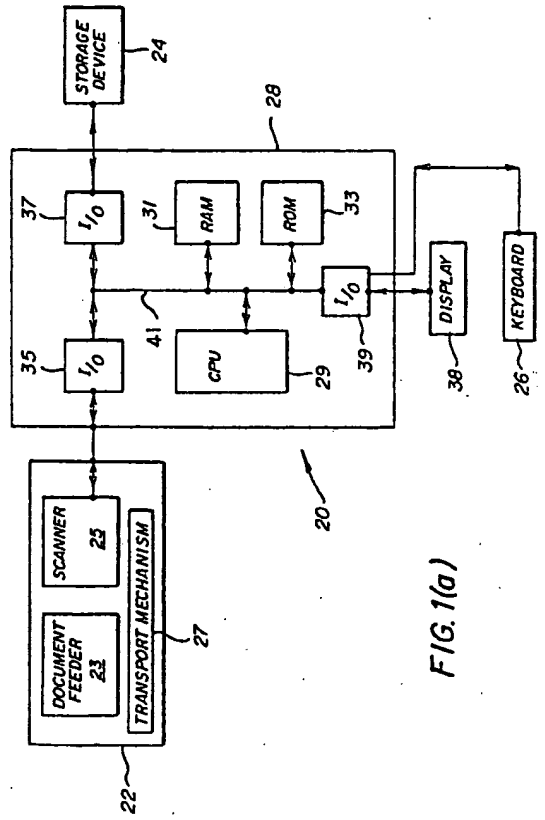

FIG. 1(a)

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of rectangularity;

FIG. 2(b) is a perspective view of a frame of information with a document image;

FIG. 3(a) is a flow chart illustrating the process for obtaining, comparing, and evaluating the attribute of linearity;

FIG. 3(b) is perspective view of a frame of information with a document image;

FIG. 3(c) is a perspective view of another frame of information with another document image;

FIG. 4(a) is a flow chart illustrating the process for obtaining, comparing, and evaluating the attribute of corner location;

FIG. 4(b) is a perspective view of a frame of information with a document image;

FIG. 5 is a flow chart illustrating the process for obtaining, comparing, and evaluating the attribute of expected fields;

FIG. 6(a) is a flow chart illustrating the process for obtaining, comparing, and evaluating the attribute of sheet skew detection;

FIG. 6(b) is a perspective view of a frame of information with a document image;

FIG. 7(a) is a flow chart illustrating the process for obtaining, comparing, and evaluating the attribute of line skew;

FIG. 7(b) is a perspective view of an initial position of four line-finding probes with respect to a document image in a frame of information;

FIG. 7(c) is a perspective view of an intermediate positions of four line-finding probes with respect to the document image of FIG. 7(b);

FIG. 7(d) is a perspective view of a final position of four line-finding probes with respect to the document image of FIG. 7(c); and

FIG. 8 is a flow chart illustrating the process for obtaining, comparing, the attribute of average character confidence.

FIG. 9 is a flow chart illustrating the process for obtaining and comparing the attribute of expected contrast;

FIG. 10 is a flow chart illustrating the process for obtaining and comparing the attribute of sharpness;

DETAILED DESCRIPTION

A document image assessment system 20 and method in accordance with one embodiment of the present invention are illustrated in FIGS. 1(a) and 1(b) respectively. System 20 includes a scanner assembly or high speed imaging device 22 and a storage device 24 which are all coupled to a programmed computer 28. System 20 and method operates by processing a document image to obtain one or more attributes related to the document image (Step 30), selecting a threshold value from a database for each of the obtained attributes (Step 32), and then comparing each of the obtained attributes against the threshold value selected for the obtained attribute to determine a difference between them for each and then using predetermined criteria to evaluate one or more of the differences to provide evaluation results of the geometrical integrity of document image. System 20 and method can also be adapted to process a document image to obtain attributes related to the condition of text in the document image and/or the condition of the document image with respect to a frame of reference. With system 20 and method, the throughput of scanner assembly 22 can be maintained while still obtaining evaluation results of the condition of each document image.

Referring more specifically to FIG. 1(a), system 20 includes scanner assembly 22 which has a document feeder 23, a scanner 25, and a document transport mechanism 27. Documents are loaded into document feeder 23 which places each document on document transport mechanism 27 which has a known uniform background. Scanner 25 scans each document against the background of document transport mechanism 27 and captures a document image of the document in a frame of information which is larger than the size of the document. Each frame of information generated by scanner 25 is represented by a number of rows and columns of pixel data. Each pixel in the pixel data has a grey scale value between 0 and 255 represented in analog form. The background of document transport mechanism 27 will have a pixel value which will be known by programmed computer 28. As a result, the computer 28 will be able to use the known pixel value of the background to distinguish the background from the document image in the frame of information. Once the scanner 25 has obtained the analog pixel data, then scanner 25 will convert the analog pixel data to digital pixel data with an analogto-digital ("A/D") converter (not shown) and then will output the digital pixel data in serial or parallel form to computer 28. A scanner assembly 22, such as the Imagelink 9XXX Series manufactured by Eastman Kodak Company, could be used.

System 20 also includes storage device 24. Storage device 24 is a memory device, such as a 68000 ADL, which stores the digital pixel data which represent the frames of information, the attributes for each document image, and the evaluation results of document images. Although not shown, storage device 24 could be incorporated within programmed computer 28.

Programmed computer 27 includes a central processing unit ("CPU") 29, a random access memory ("RAM") 31, a read only memory ("ROM") 33, input/output devices ("I/O") 35, 37, and 39, a display 38, and a keyboard 26 which are all coupled to a bus 41. I/O 35 is coupled to scanner 25 and receives the frames of information from scanner 25, I/O 37 is coupled to storage device 24 and outputs and can retrieve frames of information, attributes, and evaluation results, and I/O 39 is coupled to display 38 and keyboard 26 which can receive and output information on the assessment, threshold values, and criteria to evaluate differences. The set

termined. Once angles θ_1, θ_2, θ_3, and θ_4 are obtained, the difference between various combinations of angles are calculated to provide attributes of rectangularity (Step 72). In this particular embodiment, θ_1 minus θ_3, θ_2 minus θ_4, θ_2 minus θ_1, θ_2 minus θ_3, θ_1 minus θ_4, and θ_4 minus θ_3 are the attributes of rectangularity.

Once the attributes of rectangularity are obtained (Step 30), then the threshold value set for each attribute by the operator are selected (Step 32). Once the threshold value is selected, the difference between each attribute of rectangularity and the threshold value is determined (Step 34). In this particular embodiment, the threshold value for the difference between angles for opposing edges of document image 74 should be zero and the difference in orientation between angles for adjacent edges of document image 74 should be 90°. Specifically, the threshold values for θ_1 minus θ_3 and θ_2 minus θ_4 should be zero and the threshold values for θ_2 minus θ_1, θ_2 minus θ_3, θ_1 minus θ_4, and θ_4 minus θ_3 should be 90°. The differences between the attributes of rectangularity and threshold values are then evaluated using predetermined criteria (Step 34). In this particular embodiment, the predetermined criteria is set to accept a difference of up to 2° between the attributes of rectangularity and the threshold values. If the difference is less than 2°, then the evaluation results signal that the attribute of rectangularity is acceptable. For example, if θ_1 minus θ_3 was 1° then the evaluation results would signal that the attribute of rectangularity is acceptable, but if θ_1 minus θ_3 was 3° then the evaluation results would signal that the attribute of rectangularity is unacceptable. As discussed earlier, the particular criteria used can vary as needed and desired. Examples of criteria used in this and other examples set forth in FIGS. 3-10 for each attribute are intended to be illustrative and not exhaustive.

Referring to FIG. 3(a), a flow chart illustrates the process for obtaining, comparing, and evaluating the attribute of linearity. First, when examining the attribute of linearity, at least one edge of the document image is located in the frame of information (Step 40). Techniques for locating one edge of a document image in a frame of information are well known and thus will not be described here. Next, three sample points are placed along the located edge (Step 42). In FIG. 3(b), a frame of information 44 with a document image 46 against a fixed background is illustrated. Document image 46 has three sample points located along one edge 48 which are assigned labels A, B, and C. In FIG. 3(c), a second frame of information 50 with a document image 52 with a tear 54 is illustrated. Document image 52 has three sample points located along one edge which are assigned labels A_, B_ and C_. Although sample points A, B, and C and A_, B_ and C_ are only located along one edge 48 and 56 in this example, the sample points could be located and the process performed along each edge of document images 46 and 52. Additionally, more than three sample points could be used if desired. Next, the sample points on each document image 46 and 52 are located (Step 58) and lines are drawn between each combination of two points (Step 60). Accordingly, in FIG. 3(b) a line is drawn between points A and B to form line AB, between points A and C to form line AC, and between B and C to form line BC. In FIG. 3(c) a line is drawn between points A_ and B_ to form line A_B_, between points A_ and C_ to form line A_C_, and between points B_ and C_ to form line B_C_. Next, the angles of each line AB, AC, BC, A-B-, A-C-, and B-C- with respect to a coordinate system based on the frames of information 44 and 50 are determined (Step 62) and then the angles for each line in each frame of information 44 and 50 are compared to determine if they are equal (Step 64). The process used for determining the angles for each line is the same as that discussed earlier with respect to FIG. 2(b) and thus is not repeated again here. In FIG. 3(b), the angles for each of line AB, AC, and BC are equal, while in FIG. 3(c), the angles for each line A'B', A'C', and B'C' are not all equal because of the tear 54. The difference between the angles for each set of two lines in each frame of information 44 and 50 is averaged and this average value is the attribute of linearity for the document images 46 and 52.

Once the attribute of linearity is obtained (Step 30), a threshold value for the attribute is selected from a database in RAM 31 or ROM 33 (Step 32). Once the threshold value is selected, the difference between the attribute of linearity for each frame of information 44 and 50 and the threshold value is determined and then a predetermined set of criteria is used to evaluate each difference and to provide evaluation results (Step 34). In this particular embodiment, the threshold value is 0° and the predetermined criteria is set to allow up to 2° difference between the attribute of linearity and the threshold value. If the difference is less than 2°, then the evaluation results signal that the attribute of linearity is acceptable.

Referring to FIG. 4(a), a flow chart illustrates the process for obtaining, comparing, and evaluating the attribute of corner location. First, when examining the attribute of corner location, the edges A, B, C, and D of a document image 78 in a frame of information 80 are detected (Step 82), as shown in FIG. 4(b). Once each edge A, B, C, and D of document image 78 is identified, the coordinates for the expected corners EC_1, EC_2, EC_3, and EC_4 for document image 78 are calculated (Step 84). The document which document image 78 in FIG. 4 (b) represents has an upper left-hand corner 86 which was bent when scanned by scanner assembly 22. The dotted lines illustrate where the corner is expected to be. Next, the coordinates for actual corners AC_1, AC_2, AC_3, and AC_4 for document image 78 are detected by looking for the first light to dark transition and then dark to light transition in each row of pixels in document image 78 (Step 88). Finally, the distance between the coordinates for actual and expected corners is determined and the distance is the attribute of corner location for each corner of document image 78 (Step 90).

other line (Step 152). Collinearity is then checked again (Step 148). If the probes are collinear, then the angle of the line formed by the probes is determined and is taken as the attributes of line skew, (Step 150) as shown in FIG. 7(d). If collinearity is not found, then the process continues (Step 152) until the line is found, or all probes 128, 130, 132, and 134 are moved past a preset point in the document. In this particular embodiment, the preset point is considered to be halfway down document image 136.

Once the attribute of line skew is obtained (Step 30), a threshold value for the attribute is selected from a database in RAM 31 or ROM 33 (Step 32). In this particular embodiment, the threshold value attribute of sharpness is 0 degrees. Once the threshold value is selected, the difference between the attribute of line skew and the threshold value is determined and then the difference is evaluated using predetermined criteria to provide evaluation results (Step 34). In this particular embodiment, the predetermined criteria will allow a line skew of up to 1/2 a degree. If the difference between the attribute of line skew and the threshold value is less than half a degree, then the evaluation results signal that the attribute of line skew is acceptable. If desired, system 20 can be programmed to correct the document image for any line skew.

Referring to FIG. 8, a flow chart illustrates the process for obtaining, comparing, and evaluating the attribute of average character confidence for the entire document image. First, characters within the document image are located and processed to separate the characters from each other (Step 154). Next, optical character recognition (OCR) is performed on each character to provide an average character confidence for each character (Step 156). In this step, system 20 and method identify each different type of character in document image and then run comparisons of each different character against stored characters. A percentage likelihood of each of the identified characters matching a stored character is determined and then the average of those percentages for each character is the average character confidence for each character. System 20 and method then averages together the average character confidence for all of the characters in the document image to provide the attribute of average character confidence for the entire document image (Step 158). The attribute of average character confidence provides an indication of the condition of overall character confidence in the document image and thus an indication of the quality of the document image itself.

Once the attribute of average character confidence is obtained (Step 30), a threshold value for the attribute is selected from a database in RAM 31 or ROM 33 (Step 32). In this particular embodiment, the threshold value for average character confidence is 100%. Once the threshold value is selected, the difference between the attribute of average character confidence and the threshold value is determined and the difference is evaluated using predetermined criteria to provide evaluation results (Step 34). In this particular embodiment, the predetermined criteria will accept a difference of up to 1.5 standard deviations away from the threshold value. If the difference is within 1.5 standard deviations, then the evaluation results signal that the attribute of average character confidence is acceptable.

Referring to FIG. 9, a flow chart illustrates the process for obtaining, comparing, and evaluating the attribute of expected contrast. First, the number of black and white pixels in each row of the document image are counted (Step 94). Next, the ratio of black to white pixels for the entire document image is calculated to obtain the attribute of expected contrast (Step 96). Form documents, such as tax forms, will have the same ratio of black to white pixels in the document images each time the documents are scanned.

Once the attribute of expected contrast is obtained (Step 30), a threshold value for the attribute is selected from a database in RAM 31 or ROM 33 (Step 32). In this particular embodiment, the threshold value is a mean ratio of black to white pixels obtained from scanning a number of the same type of documents. Once the threshold value is selected, the difference between the attribute of expected contrast and the threshold value is determined and then the difference is evaluated using predetermined criteria to provide evaluation results (Step 34). In this particular embodiment, the predetermined criteria will accept a difference of up to one standard deviation above or below the threshold value. If the difference is within one standard deviation, then the evaluation results signal that the attribute of expected contrast is acceptable.

Referring to FIG. 10, a flow chart illustrates the process for obtaining, comparing, and evaluating the attribute of sharpness. The attribute of sharpness provides an indication of how blurred the document image may be and whether the document image is suitable for further processing. First, the document image is located in the frame of information (Step 108). Once the document image is located, then the frequency of black to white pixels per line of the document image is obtained and is used as the attributes of sharpness (Step 110). Each type of form document, such as a tax form, will have a unique frequency of black to white pixels.

Once the attribute of sharpness is obtained (Step 30), a threshold value for the attribute is selected from a database in RAM 31 or ROM 33 (Step 32). In this particular embodiment, the threshold value is a mean frequency obtained from scanning a number of the same type of documents. Once the threshold value is selected, the difference between the attribute of sharpness is determined and the difference is evaluated using predetermined criteria to provide evaluation results (Step 34). In this particular embodiment, the predetermined criteria will accept a difference of up to 10% from the threshold value. If the difference is within 10%, then the evaluation results signal that the attribute of sharpness

locating the sample points;
analyzing sets of three points in each section for collinearity; and
determining the angle of a line connecting the three most collinear points to obtain an attribute of sheet skew.

10. The method as set forth in Claim 1 further comprising the steps of:

processing the document image to obtain attributes related to line skew and average character confidence in the document image;
selecting a threshold value from a database for each of the obtained attributes; and
comparing each of the obtained attributes against the threshold value selected for the obtained attribute to determine the difference for each and then evaluating one or more of the differences using predetermined criteria to provide evaluation results of the condition of the text of the document image.

11. The method as set forth in Claim 10 wherein the step of processing the document image to obtain the attribute of line skew comprises:

detecting the location of the document image;
generating a bounding box around the document image;
locating at least three probes along the top edge of the bounding box;
moving each of the probes down one row of pixels at a time in the document image until each of the probes detects a line;
determining if each of the three probes is collinear;
moving the probe which has moved the least to the next line if the probes are not collinear; and
determining the angle of the line when the probes are collinear to obtain the attribute of line skew.

12. The method as set forth in Claim 10 wherein the step of processing the document image to obtain the attribute of average character confidence comprises:

detecting the location of the document image;
locating and processing each character in the document image;
performing optical character recognition on each located character and obtaining an average character confidence for each character; and
averaging all of the average character confidence for each character obtained to obtain the attribute of average character confidence for the document image.

13. The method as set forth in Claim 1 further comprising the steps of:

processing the document image to obtain attributes related to expected contrast and sharpness;
selecting a threshold value for each of the obtained attributes; and
comparing each of the obtained attributes against the threshold value selected for the obtained attribute to determine a difference for each and then evaluating one or more of the differences using predetermined criteria to provide evaluation results of the condition of the document image with respect to a fixed reference.

14. The method as set forth in Claim 13 wherein the step of processing the document image to obtain the attribute of expected contrast comprises:

detecting the location of the document image; and
counting the number of black and white pixels in the document image to obtain the attribute of expected contrast.

15. The method as set forth in Claim 13 wherein the step of processing the document image to obtain the attribute of sharpness comprises:

detecting the location of the document image; and
determining the frequency of black to white pixels per line of the document image to obtain the attributes of sharpness.

16. A system for assessing a document image, the system comprising:

means for processing one or more of the document images to obtain one or more attributes related to the geometrical integrity of each of the document images;
means for selecting a threshold value for each of the attributes from a memory; and
means for comparing each of the obtained attributes against the threshold value selected for the obtained attribute to determine the difference for each and the evaluating one or more differences to provide evaluation results on the geometrical integrity of the document image.

17. The system as set forth in Claim 16 further comprising a scanner assembly for scanning documents to obtain the document images, the scanner assembly

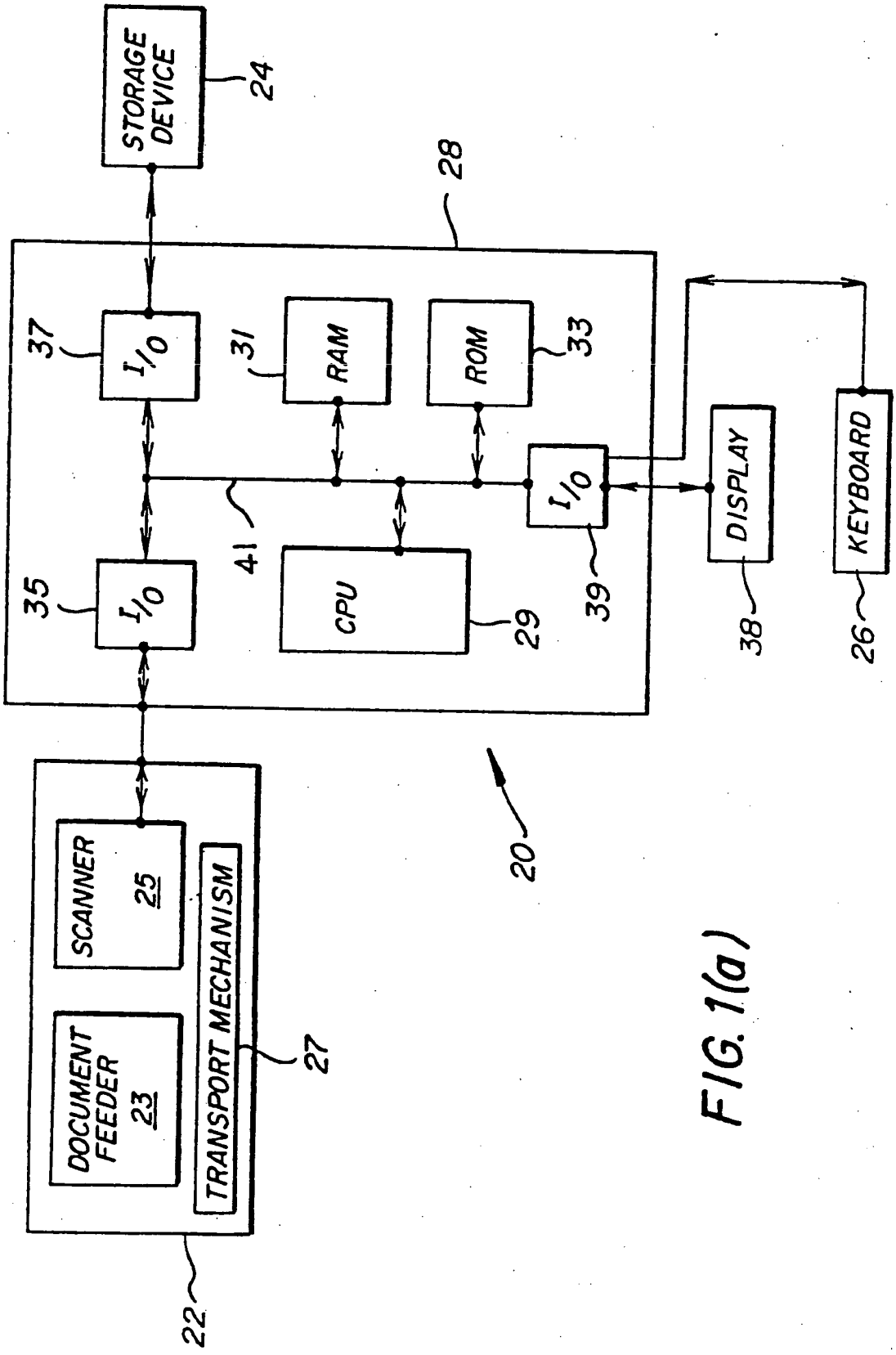
STORAGE DEVICE
24
28
37
I/O
31
RAM
ROM
33
I/O
DISPLAY
KEYBOARD
35
I/O
41
CPU
29
39
38
26
20
SCANNER
25
DOCUMENT FEEDER
23
TRANSPORT MECHANISM
27
22

FIG. 1(a)

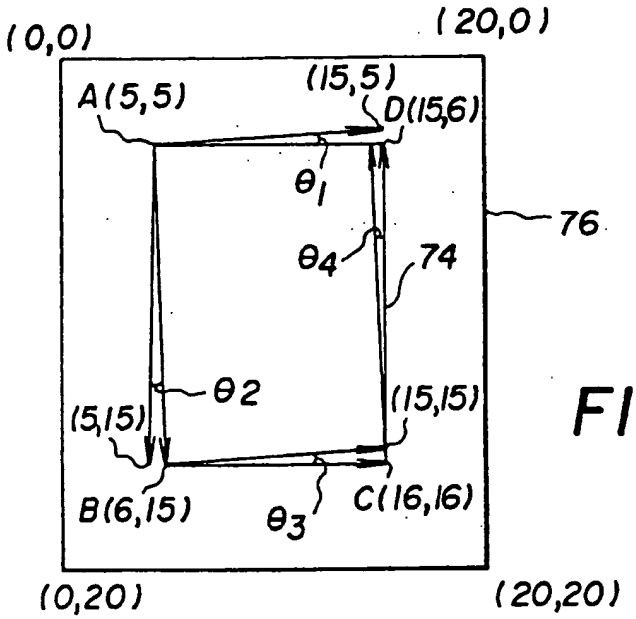

FIG. 2(b)

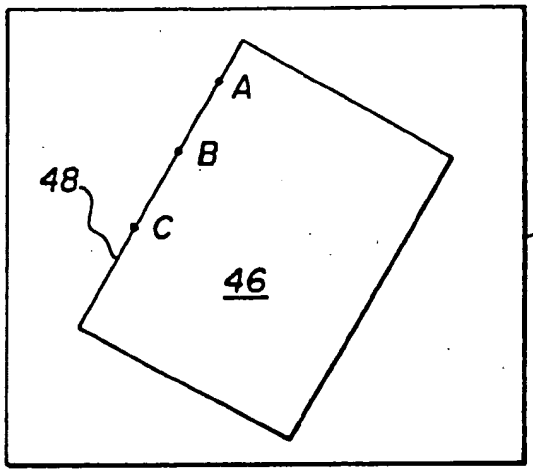

FIG. 3(b)

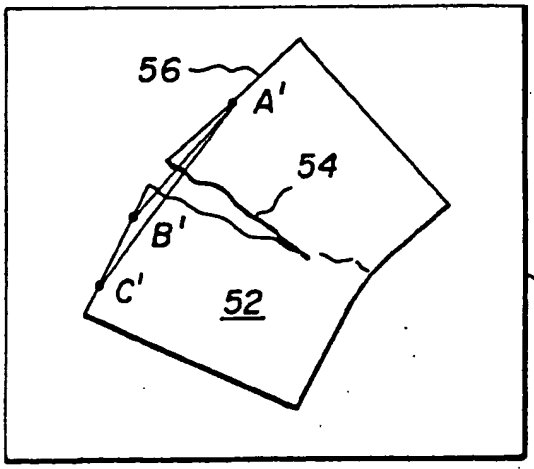

FIG. 3(c)

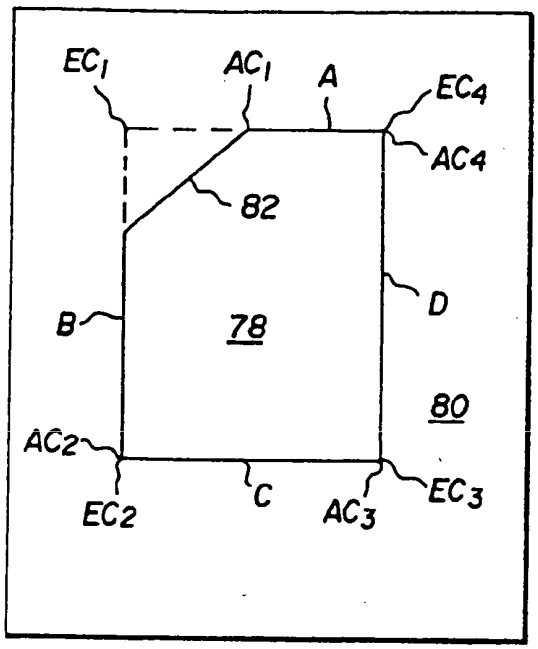
EC1
AC1
A
EC4
AC4
82
D
B
78
80
AC2
C
EC2
AC3
EC3

FIG. 4(b)

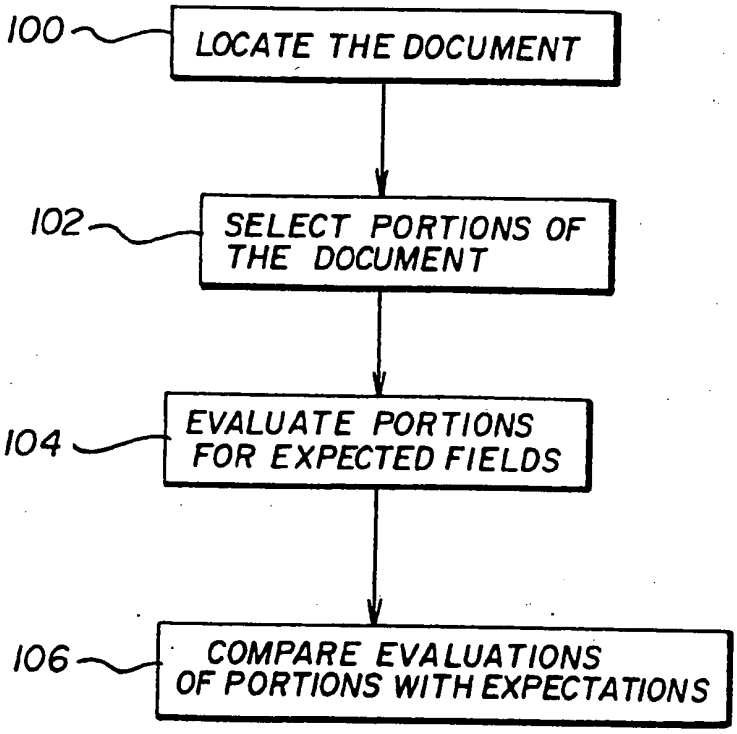
100
LOCATE THE DOCUMENT
102
SELECT PORTIONS OF THE DOCUMENT
104
EVALUATE PORTIONS FOR EXPECTED FIELDS
106
COMPARE EVALUATIONS OF PORTIONS WITH EXPECTATIONS

FIG. 5

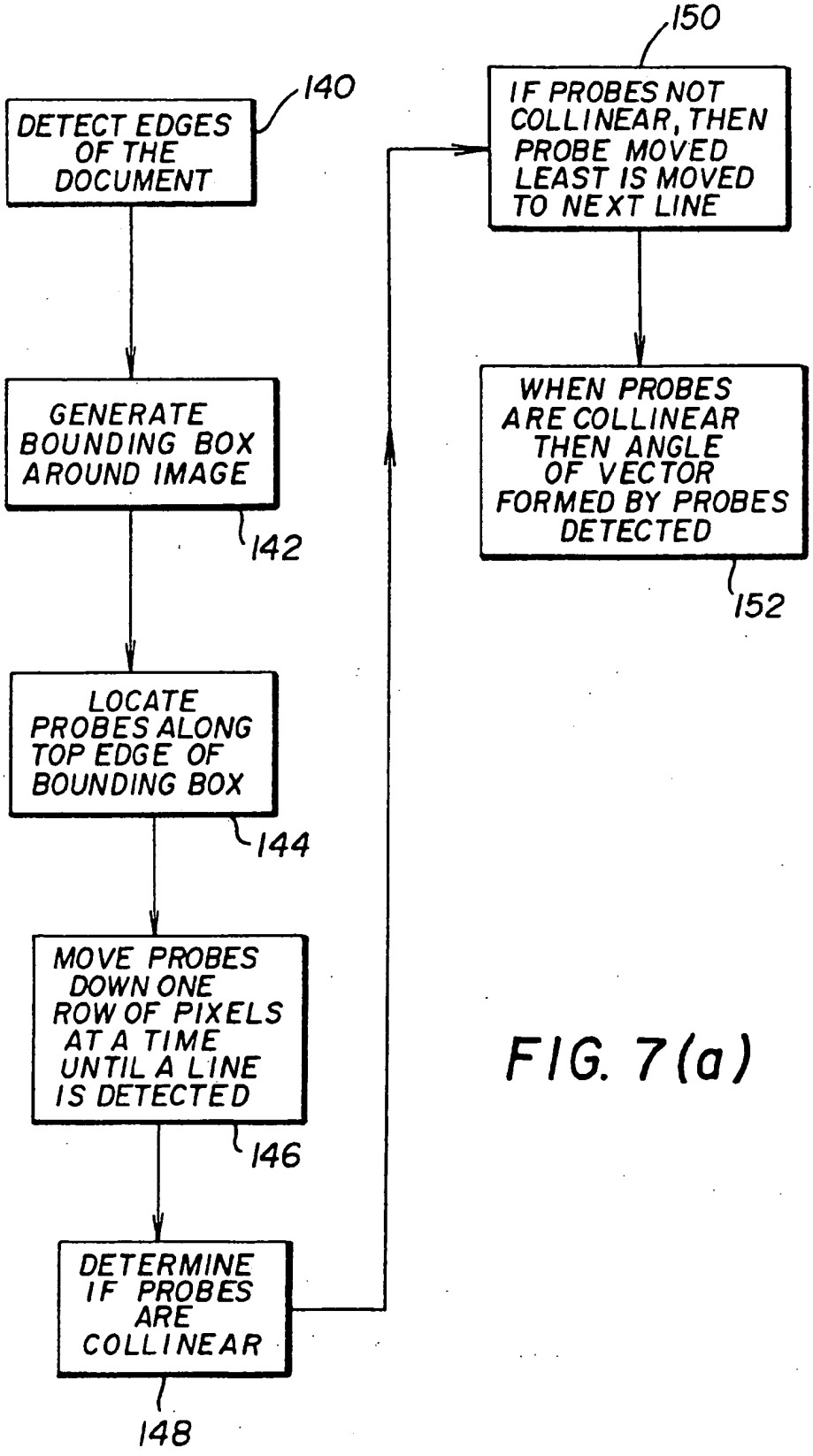
DETECT EDGES OF THE DOCUMENT
140
GENERATE BOUNDING BOX AROUND IMAGE
142
LOCATE PROBES ALONG TOP EDGE OF BOUNDING BOX
144
MOVE PROBES DOWN ONE ROW OF PIXELS AT A TIME UNTIL A LINE IS DETECTED
146
DETERMINE IF PROBES ARE COLLINEAR
148
IF PROBES NOT COLLINEAR, THEN PROBE MOVED LEAST IS MOVED TO NEXT LINE
150
WHEN PROBES ARE COLLINEAR THEN ANGLE OF VECTOR FORMED BY PROBES DETECTED
152

FIG. 7(a)

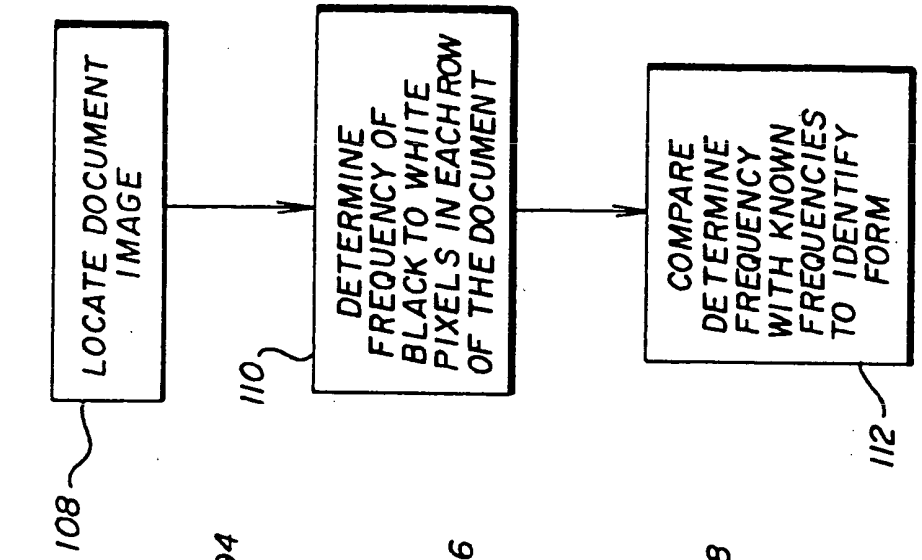

FIG. 10

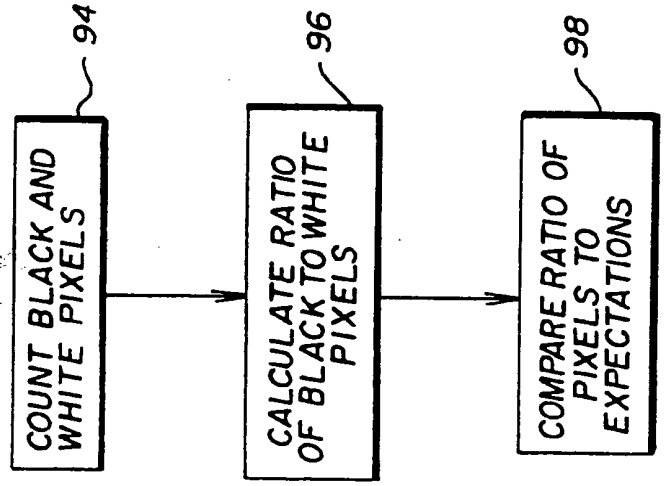

FIG. 9

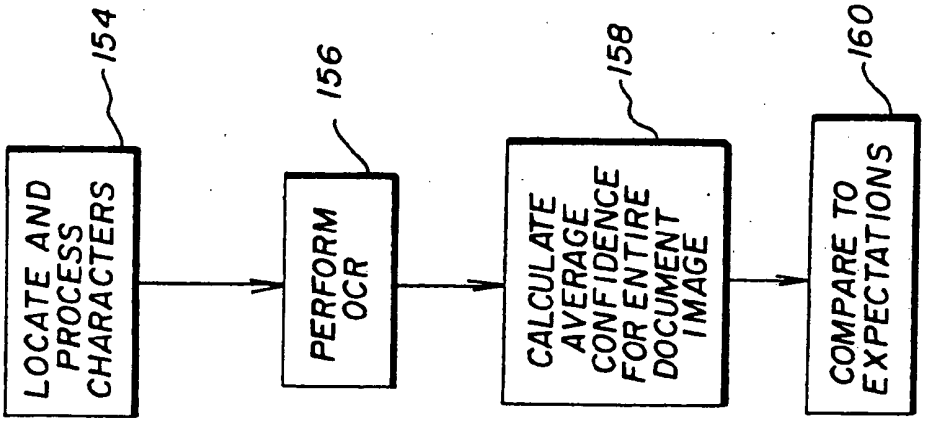

FIG. 8

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 96 42 0013

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A	IBM TECHNICAL DISCLOSURE BULLETIN, vol. 35, no. 4A, September 1992, NEW YORK, US, pages 424-428, XP002002240 ANONYMOUS: "Real-time Edge Detection Rotation of Check Images." -----	10,20	

TECHNICAL FIELDS SEARCHED (Int.Cl.6)

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
MUNICH	7 May 1996	Farman, T

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)